

# SUBARU/IRCS Infrared Spectroscopy of the Pluto

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# Pluto-Charon system

- Pluto

- Diameter : 2300km
- Semi axis : 39.5AU
- Eccentricity : 0.249
- Inclination : 17.14°

- Charon

- Satellite of the Pluto
- Diameter : 1200km

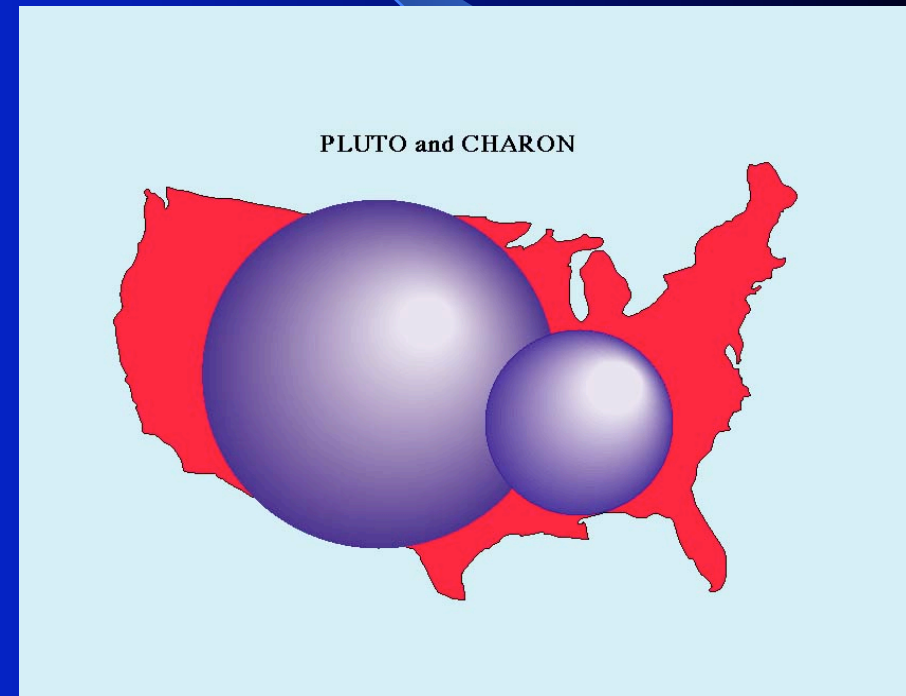


Fig1. PLUTO and CHARON

# Edgeworth-Kuiper Belt Objects (EKBOs)

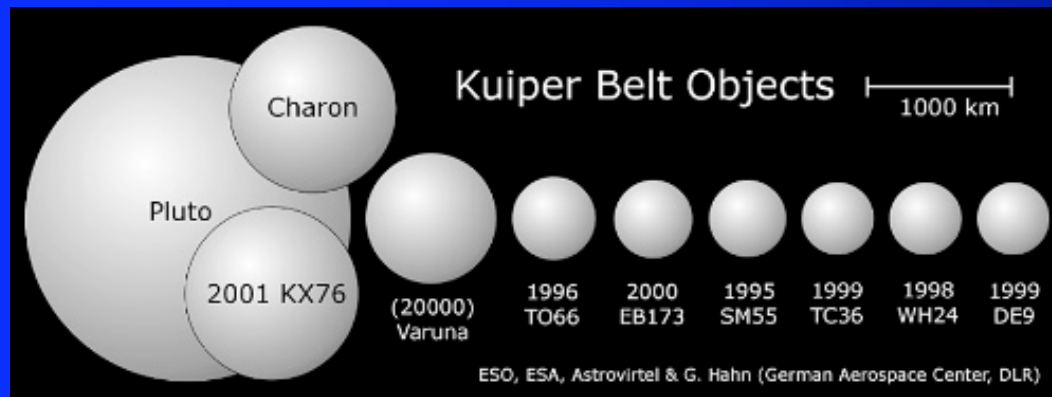


Fig2. Pluto, Charon, and some EKBOs

Pluto = the largest EKBOs ?

Charon = EKBOs ? Formed by Giant Impacts of Pluto?

⇒ Surface composition of the Pluto/Charon system is the key for revealing the origin of the EKBOs.

# Previous study

- *1999, SUBARU/CISCO*
  - The absorption bands of **solid ethane** were confirmed in the **K-band** (1.93-2.48 $\mu\text{m}$ ). (Nakamura *et al.*, 2000)
- *2000, IRTF/SpeX*
  - The spectroscopic data was obtained in the **L-band** (2.84-4.16 $\mu\text{m}$ ).
    - They *can't* confirmed the absorption bands of solid ethane. (Grundy *et al.*, 2002)

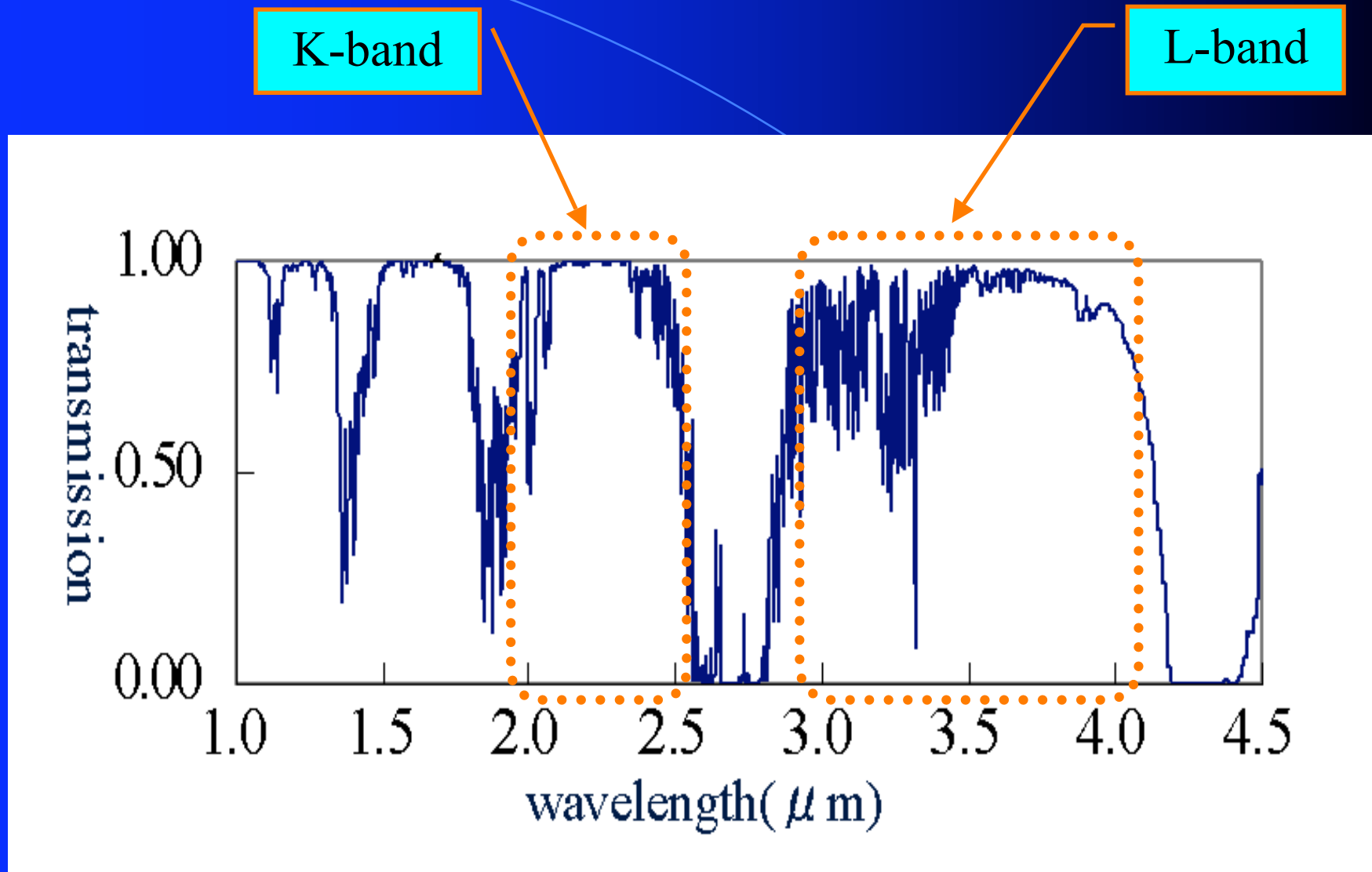


Fig3. Atmospheric absorption lines at Mauna Kea

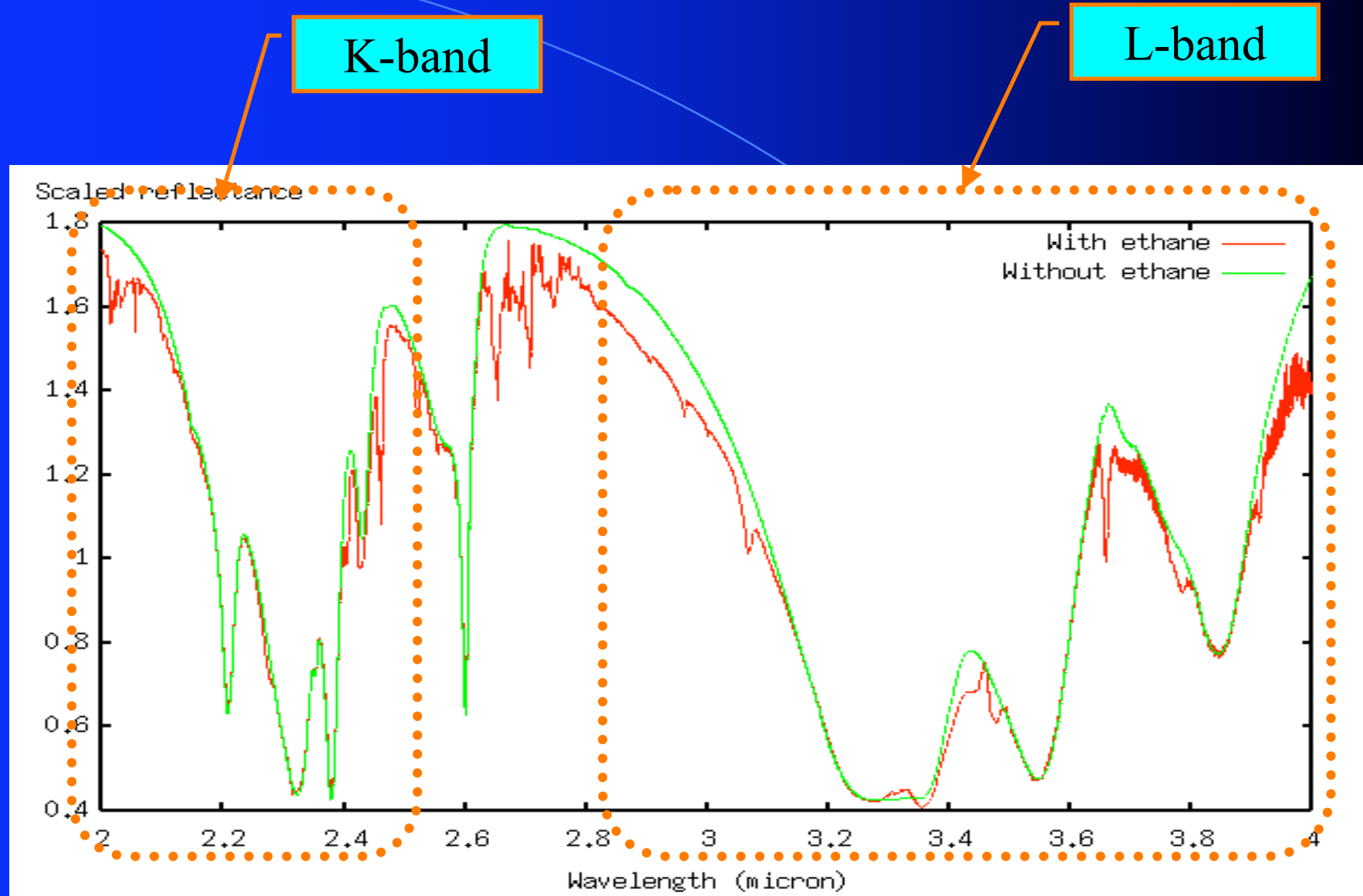


Fig4. Difference between 'with ethane' and 'without ethane'

# Our purpose of this study

- Verification of solid ethane on the Pluto
  - Data : 2002, SUBARU/IRCS (L-band)

## Why looking for ethane?

Ethane is not formed in the *equilibrium condensation model* of the solar system. Therefore the existence of ethane could gives clues in revealing the thermal history of the solar system.

# Origin of ethane

- Origin of solid ethane on the Pluto
  - 1. External cause: addition by comets  
comet  $\rightleftharpoons$  interstellar matter
  - 2. Internal cause: well up from the Pluto's interior  
ethane was formed in the differentiation process
  - 3. Photochemical reactions

# Observations

- Observational day:  
2002, May 28 ~ 29
- Observation site:  
Mauna Kea, Hawaii
- Instruments:  
Subaru Telescope  
IRCS (Infrared Camera and Spectrograph)  
AO (Subaru Adaptive Optics system)



# Method to analyze

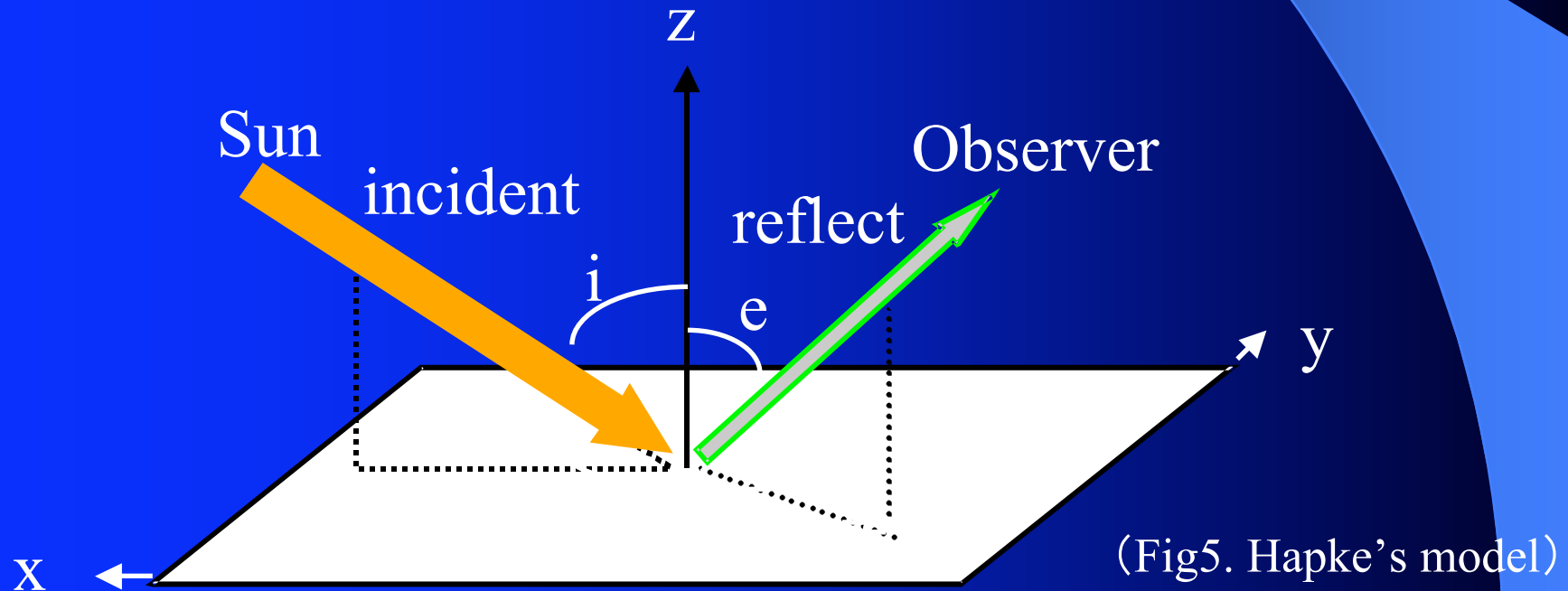
- IRAF (image analysis software) :  
observational data → spectrum of the Pluto
- Numerical simulation :  
estimate  $C_2H_6/CH_4$  ratio on the Pluto

## Numerical method

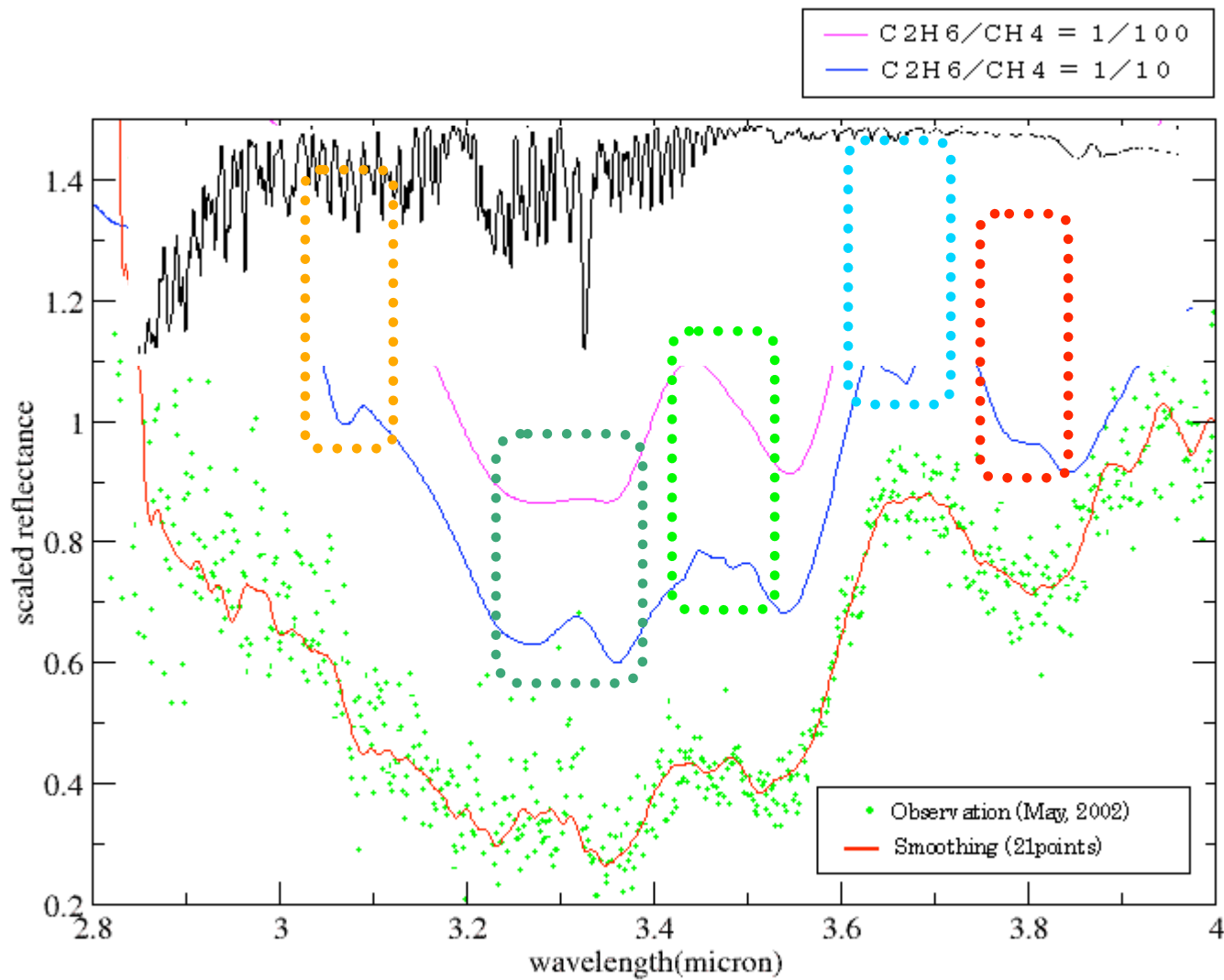
- The bidirectional reflectance model (Hapke, 1993)
- 4 components:  $N_2$ ,  $CH_4$ ,  $CO$ ,  $C_2H_6$

# The bidirectional reflectance model (Hapke, 1993)

$$r = \frac{\omega}{4\pi} \frac{\mu_0}{\mu_0 + \mu} \{ [1 + B(\alpha)] p(\alpha) + H(\mu_0)H(\mu) - 1 \} S$$

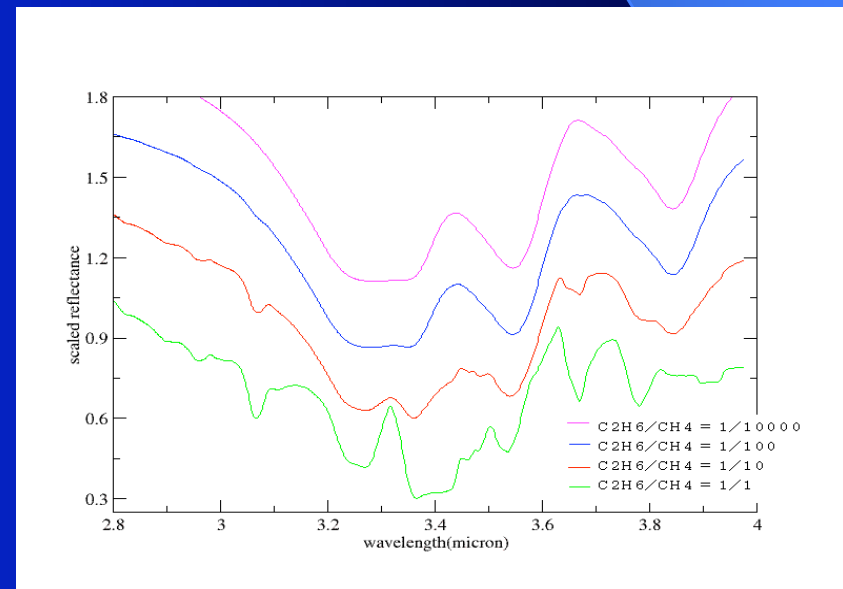
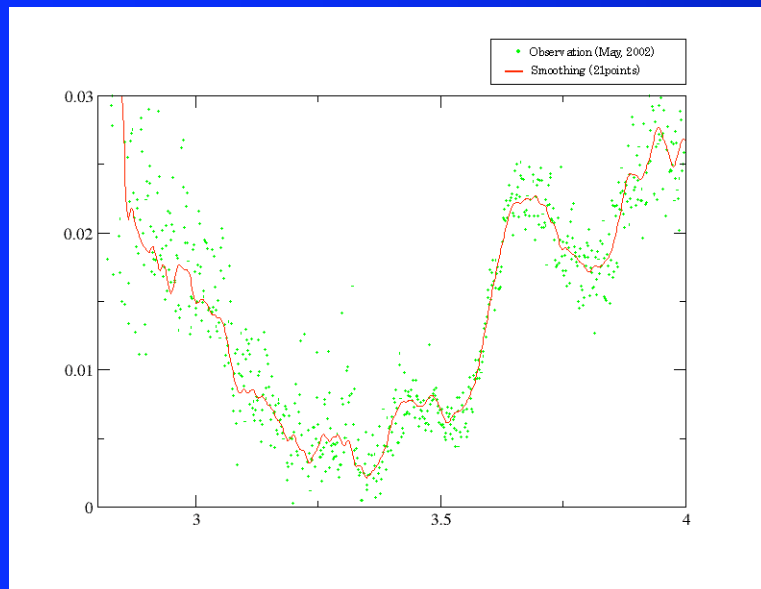


# Pluto L band



# Result of L band

- The absorption bands of ethane is confirmed!
- Compared to model simulations;  $C_2H_6/CH_4$  ratio is approximately **10/1**.



# Discussion

- We confirmed solid ethane's absorption.
- Estimated  $C_2H_6/CH_4$  ratio  $\sim 1/10$



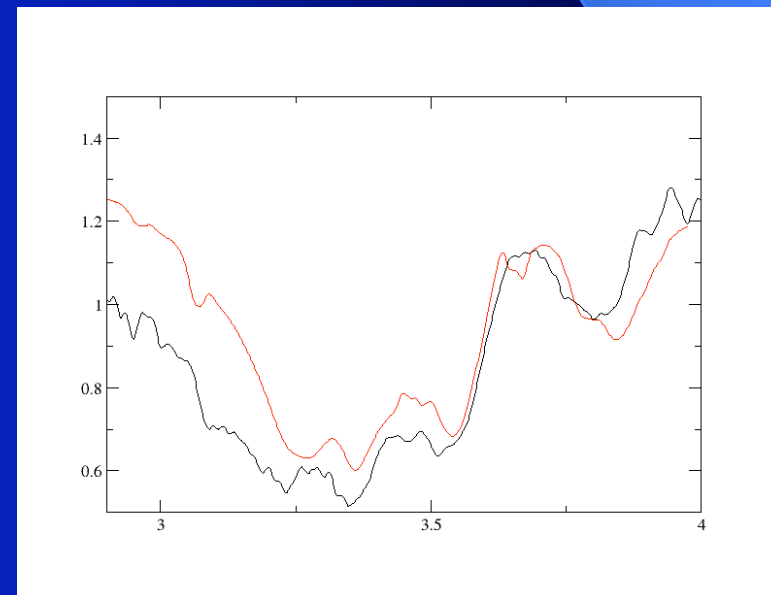
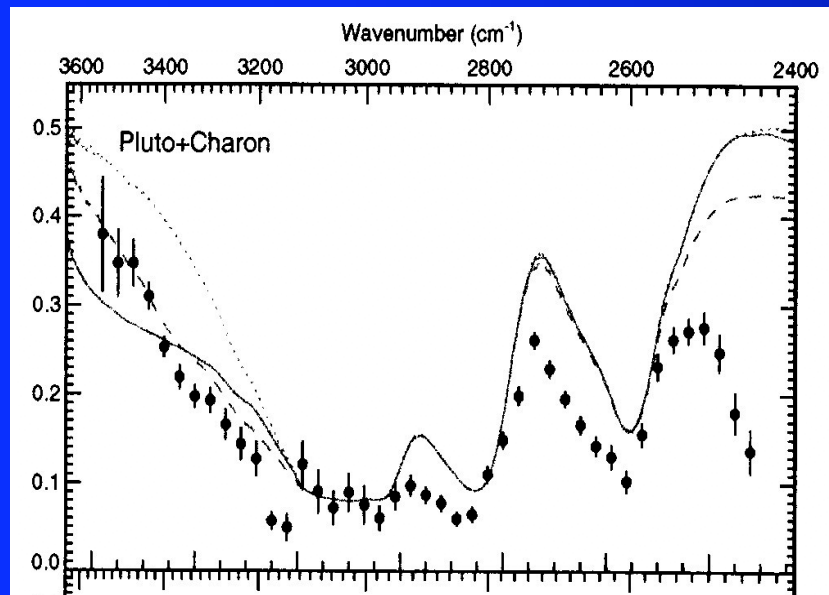
- Equilibrium Condensation  $\sim 1/10000$

(Fegley and Prinn, 1989)

The material on Pluto's surface likely went through a special thermal history or special evolution process.

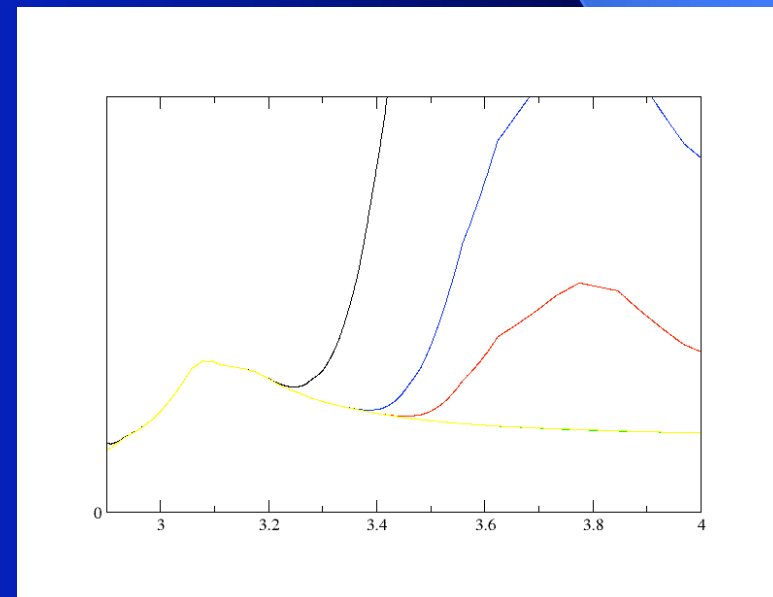
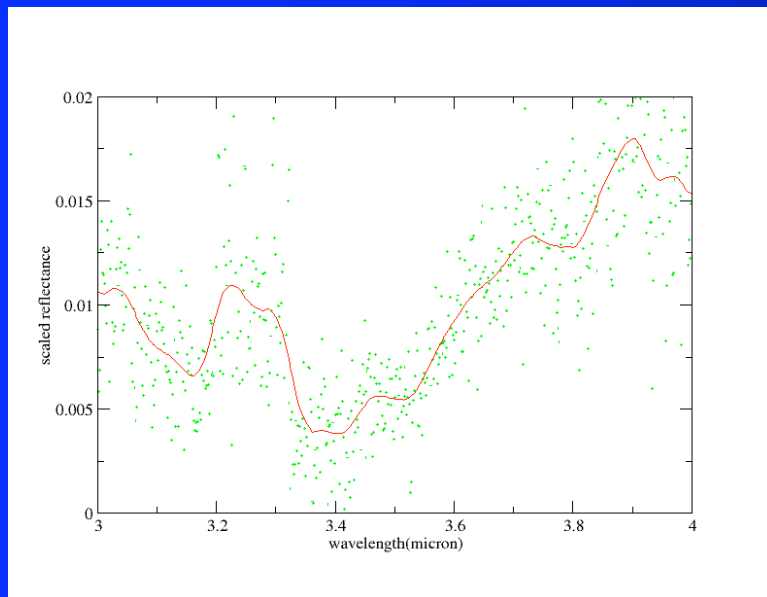
# Compared with IRTF

- Our result does not require SO<sub>2</sub> or CO<sub>2</sub> ice.
- Global absorption in shorter wavelength could explainable by H<sub>2</sub>O ice.



# Result of Charon

- The absorption bands of H<sub>2</sub>O is confirmed?
- Compared to model simulations; grain size is approximately 50  $\mu\text{m}$ ?



# Summary

- We present the spectroscopic data obtained in the L-band using SUBARU Telescope and reexamine the presence of solid ethane on Pluto.
- We confirm the absorption of solid ethane and estimate  $C_2H_6/CH_4$  ratio is approximately **10/1**.
- The material on Pluto's surface likely went through a special thermal history or special evolution process.